Original article

Long-term outcome of operative management of delayed acetabular fractures

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Keywords: *fractures; acetabulum; operations; outcome assessment*

Background Surgical treatment of acetabular fracture has long been a challenging area in the field of orthopedic trauma. The aim of this research was to investigate the operative methods for delayed acetabular fractures and to assess the operation results.

Methods The operative approaches, procedures, results, and complications of the delayed acetabular fractures between 1995 and 2005 were retrospectively evaluated at Beijing Jishuitan Hospital. Quality of life was assessed for each patient with the Merle d'Aubingne and Postel fracture function rating scale and the radiological result was assessed using the Matta radiological score.

Results Sixty-eight cases (70 hips) were followed up with a minimal duration of five years (average of 5.8 years). Excellent functional results were observed in 10 hip joints, good results in 40, fair results in 11, and poor results in nine. The risks of poor prognosis include impact fracture or osteochondral fracture of femoral head, a time beyond 42 days from injury to operative management, and dislocation of femoral head during the injury. Some of the problems, which were observed included postoperative infection in two hips, iatrogenic sciatic nerve injury in eight hips, traumatic arthritis in 15 hips, heterotopic ossification in 17 hips, and necrosis of the femoral head in six hips.

Conclusion A careful selection of operative indications for delayed acetabular fractures in combination with a proper operative approach and appropriate reduction and fixation could guarantee relatively good results.

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As the anatomy of acetabular fracture is relatively complicated, the surgical exposure, reduction, and fixation of this injury are rather difficult. Surgical treatment of acetabular fracture has long been a challenging area in the field of orthopedic trauma. A delayed acetabular fracture with duration of more than three weeks is hard to be corrected with surgery, which could be due to malunion, absorption of fracture line, and scar formation between the bone fragments. The operative result is poor as compared to the fresh fractures. In this study, 68 patients (70 hips) were followed up and the outcome and the risk of long-term prognosis were analyzed.

METHODS

Patients

Our department received 103 patients experiencing acetabular fracture with more than 3-week delays from 1995 to 2005. From among them, 54 patients had delayed fractures upon admission and the remaining 49 had severe associated injuries. In all cases, it was after 3 weeks that the surgery was performed. Most of the hip dislocations did not gain proper reduction before the final treatment.

An admission protocol was followed for all local and inter-hospital transfers. The data recorded included the mechanism of injury, classification of the fracture, associated injuries, complications, and comorbidities. Standard plain radiographs, including anteroposterior pelvis, obturator oblique and iliac oblique views, and CT scans and 3D reconstruction were obtained to assess and classify all the fractures preoperatively.

Surgical procedure

The purpose of the surgical management in cases of delayed acetabular fracture is the same as fresh fracture. To acquire a satisfactory reduction, most delayed acetabular fractures require combined approaches to reach a full exposure and a complete release. In some occasions, osteotomy technique is necessary for the cases of severe malunion. Single surgical approach, such as Kocher-Langenbeck approach, or ilioinguinal approach was performed in 92 patients. The combined approach was used in 10 patients of malunion or nonadequate reduction through single approach. Interfragment release is key to the treatment of delayed acetabular fractures. Surgeons need to carefully clean the soft tissue and callus until the fracture line is identified. For column fractures, the fracture gap needs to be cleaned up from the interpositioned scar, callus, and surrounding soft

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tissue. For wall fractures, the attachment of capsule and soft tissue should be carefully protected to avoid avascular necrosis. But in cases where the fracture was a malunion and the original fracture line could not be identified, an osteotomy technique was the only choice. For some severely injured patients with femoral head dislocation, postoperative skeletal traction was sometimes required to decrease the intra-articular pressure, especially for posterior wall bony defects reconstructed with autografts. In this study, 39 patients associated with delayed posterior or central dislocation of femoral head were assessed. Postoperative skeletal traction also maintains 3–6 weeks in the patient of nonperfect reduction of acetabular fracture or femoral dislocation.

Assessments

X-ray examination was routinely applied to each patient. The CT and MRI were selectively performed. Matta radiological score and Merle d'Aubingne & Postel fracture function rating scale were used in the follow-up.

Statistical analysis

All data were analyzed using SPSS version 15.0 (SPSS Inc., Chicago, IL, USA) and categorical data were expressed as frequency (percent). The χ^2 test was used for categorical data and a P of less than 0.05 was regarded statistically significant.

RESULTS

From among 103 patients, 68 (70 hips) were available for full follow-up evaluation including 39 left and 31 right. Both of the two bilateral side delayed acetabular fractures were operatively treated. A total of 57 males and 11 females were enrolled, with the average age of 39.5 years (17–64 years). The average follow-up time was 5.8 years (5–9 years). Thirty-seven patients were admitted in less than 21 days following the initial injury, while the other 31 patients were categorized under delayed fracture. According to the Letournel-Judet acetabular fracture classification, there were 25 posterior wall fractures, nine transverse fractures, two anterior column fractures, one posterior column fracture, 20 transverse plus posterior wall fractures, two posterior column plus posterior wall fractures, four T shaped fractures, and seven both column fractures. Thirty-three of the original injuries were associated with posterior dislocation and seven were associated with central dislocation of the hip joint, but only six of them were adequately reduced.

Causes of injury included 59 traffic accidents, six pound injuries, two fall injuries, and one crush injury. Furthermore, 35 cases had associated injuries including nine with chest injuries, four with brain injuries, four with intestinal perforation, one with hepatorrhexis, one with splenic rupture, two with burn injuries, 18 with lower extremity fractures, nine with upper extremity fractures, eight with pelvic fracture of the opposite side, and two with lumbar fractures.

The average delay from the time of injury to surgery was 49 days (range 21–235 days) including 21–30 days in 31 cases (47.1%), 31–60 days in 21 cases (30.0%), 61–90 days in eight cases (11.4%), 91–120 days in two cases (2.9%), and over 120 days in six cases (8.6%).

Intraoperative conditions

In terms of choices of surgical approach, Kocher-Langenbeck approach was adopted in 54 sides including 25 posterior wall fractures, one posterior columns, two posterior columns plus posterior wall fractures, 19 transverse fractures plus posterior wall fractures, four transverse fractures, two T-shaped fractures, and one both column fractures. Ilioinguinal approach was adopted in 10 sides including two anterior column fractures, four transverse fractures, and four both column fractures. Iliofemoral approach was adopted in only one side, which was a T-shaped fracture. A combined anterior and posterior approach was adopted in five sides including one transverse fracture, one transverse and posterior wall fracture, one T-shaped fracture, and two both column fractures (Table 1). The average surgical time was 195 minutes (range 90–480 minutes). The intraoperative reinfusion of autologous blood transfusion was adopted in 48 patients with the average volume of 775 ml (range 200–3700 ml). Although 18 patients did not receive allogeneic blood transfusion, the average volume of the allogeneic blood transfusion among the other patients was 2116 ml (range 600–14 200 ml).

Forty-nine nonunion type fractures were confirmed during the surgery. The other 21 sides were accompanied with malunion and five sides required osteotomy (pubis ischium branch and iliac crest) to identify the original fracture line. The trochanteric osteotomy was performed following the Kocher-Langenbeck approach in eight sides and combined anterior and posterior approach in two sides in order to extend the exposure. Five sides of the original injuries were associated with posterior dislocation of the hip joint, which required the resection of the quadratus femoris to release the soft tissue contracture and to relocate the femoral head. Four sides with compressive deformation of femoral head and five sides with the abrasion of the femoral head cartilage surface were observed. The autologous bone grafts that were harvested from the posterosuperior iliac crest were applied in five sides in order to reconstruct the posterior wall. Furthermore, 18 sides needed postoperative skeletal traction with an average time of 3 weeks.

Table 1. Classification and surgical approach

Approaches	PW	TV	PC	AC	TV+PW	PC+PW	TS	BC	Total
K-L	25	4	1	0	19	2	2	1	54
I-I	0	4	0	2	0	0	0	4	10
Iliofemoral	0	0	0	0	0	0	1	0	1
Combined	0	1	0	0	1	0	1	2	5
Total	25	9	1	2	20	2	4	7	70

PW: posterior wall fracture; TV: transverse fracture; PC: posterior column; AC: anterior column; TV+PW: transverse with posterior wall fracture; PC+PW: posterior wall with posterior column fracture; TS: T-shape fracture; BC: both column fracture.

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Clinical outcomes

The radiological examination along with modified Merle d'Aubingne & Postel fracture function rating scales were used for the final follow-up. According to Matta radiological score, nine hips were excellent, 40 were good, 12 were fair, and nine were poor with an acceptance rate of 70%. We further used the modified Merle d'Aubingne & Postel fracture function rating scale as a measure of the functional status in our patients. As a result, 10 hips were excellent, 40 were good, 11 were fair, and nine were poor with an acceptance rate of 71.4% (Table 2, Figure 1).

Statistical analysis

The time from injury to operation was recorded in all cases to analyze the risks and final functional results. These included the cases with associated injuries especially fractures of lower extremities, femoral head dislocation, impact fractures, osteochondral fracture, skeletal traction, and nerve injury of the lower extremities. The χ^2 test was used to identify the impact or osteochondral fractures of the femoral head that were delayed more than 42 days as well as preoperative dislocation of femoral head as the risk factors for a bad outcome (Table 3).

Table 2. Classification and functional score

Scores	PW	TV	PC	AC	TV+PW	PC+PW	TS	BC	Total
Excellent	2	1	0	1	5	0	0	1	10
Good	15	5	1	0	10	2	3	4	40
Fair	4	3	0	0	2	0	1	1	11
Poor	4	0	0	1	3	0	0	1	9
Total	25	9	1	2	20	2	4	7	70

PW: posterior wall fracture; TV: transverse fracture; PC: posterior column; AC: anterior column; TV+PW: transverse with posterior wall fracture; PC+PW: posterior wall with posterior column fracture; TS: T-shape fracture; BC: both column fracture.

Figure 1. The X-rays of a 23-year-old male. **A:** The fracture type was classified as bilateral transverse and posterior wall fractures, associated with hip joint posterior dislocation. **B:** The surgery was performed at 25 days after the injury and bilateral K-L approach was adopted. **C:** Follow-up at 5 years after the surgery showed a Brooker I grade heterotopic ossification that was occurred in the right hip, slight subchondral sclerosis of the acetabulum, and joint space narrowing on the left. The function was satisfactory, according to the modified Merle d'Aubingne & Postel functional score (18 points of the right side and 17 of the left).

Complications

The main complication was infection in two patients. One of them had a posterior wall fracture associated with posterior dislocation of the hip joint. After being primarily treated with open reduction internal fixation (ORIF) in a local hospital, the femoral head and acetabulum were still poorly matched. The surgery delay had exceeded three months when the patient was transferred to our institute. Deep tissue infection was encountered after revision surgery. After repeated debridement, implantation of antibiotics bone cement bead chain and removing part of the internal fixation, the infection was effectively controlled. However, the motion of the hip joint was completely lost and the final function was poor. The other patient had a superficial infection, which was managed successfully.

Twenty-two hips encountered sciatic nerve palsies. Of those, 14 were associated with original injuries and eight with iatrogenic injuries. Full-recovery was seen in eight hips with traumatic causes and two hips with iatrogenic injuries. Others were still suffering residual weakness of ankle and toe dorsiflexion in the last follow-up. All the fractures were healed by the time of follow-up. Fifteen hips (21.4%) developed posttraumatic osteoarthritis, 17 hips developed heterotopic ossification (24.3%), four of which were categorized as Brooker IV grade. Osteonecrosis of the femoral head and a combined delayed dislocation of femoral head were observed in 11 (15.7%) patients and nine hips (12.9%) respectively. Two patients could not tolerate the complications and received total hip replacement (THR).

DISSCUSION

Treatment methods for displaced delayed acetabular fractures: ORIF or primary THR?

For the delayed acetabular fracture, the debate is whether the ORIF would make any sense. Based on our experience, since a final treatment with ORIF is necessary for young patients, once the perfect reduction is achieved, it would be possible to obtain a satisfactory prognosis. Even if the result is not satisfactory, a second THR can be conducted, where the structure restoration in the post-ORIF patients would be more anatomical. In cases where joint salvage was deemed impossible, restoration of the columns for subsequent THR was the aim.[1] Lai et al[2] compared the different methods of restoration and reported that anatomical restoration was positively related to fracture treatment, without any

Table 3. Risks of functional outcome (*n*)

PMA	Femoral head impact fracture or osteochondral fracture		Period from injury to operation		Femoral head dislocation preoperatively		Skeletal traction preoperatively		Nerve injury of lower extremity	
	Yes	No	≤42 days	>42 days	Yes	No	Yes	No	Yes	No
≥14	3	47	39	11	20	30	33	17	14	36
<14	6	14	10	10	14	6	11	9	8	12
Total	9	61	49	21	34	36	44	26	22	40
Values	7.344		5.333		5.147		0.740		0.955	
P values	0.013*‡		0.021*†		0.023*†		0.390†		0.329†	

*Significant statistical difference; †Pearson χ^2 test; ‡Fisher χ^2 test; PMA: modified Merle d'Aubingne & Postel functional score.

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significant difference between ORIF and conservative treatment. The operation time and blood loss in the ORIF patients were significantly more than that of the nonsurgical patients. Zhang et al[3] analyzed 53 patients who underwent THR due to a failed acetabular fracture treatment, where the average postoperative Harris score was significantly higher in the ORIF group as compared to that of the non-ORIF group. In the study of Ranawat et al[4] and Sermon et al,[5] similar results were observed; however, there was no significant difference between the ORIF and non-ORIF groups. In addition, the prosthesis life is a big limitation for primary THR; delay in the THR time can reduce the times of prosthesis revision. According to these results, ORIF is a good choice even for the older patients who were injured within 42 days.

Surgical treatment

The aim of the surgical management for the delayed acetabular fracture is similar to that of the fresh fracture: to reconstruct the articular surface, to stabilize the fragments, to recover the range of motion for the hip joint, to relieve the pain, and to have a good preparation for the secondary THR. For the nonunion cases, the surgeon needs to carefully clean the soft tissue and callus until the fracture line is identified. The fragments are then gradually and completely released and are intraoperatively reduced to their original anatomical position. For the malunion cases, it is often difficult to identify the primary fracture line through the cortical plate. Under such circumstances, the surgeon could expose the joint through osteotomy, since the healing of the osteochondral fracture might not occur as well as bones; the fracture line could be found intra-articularly. If not injured, the femoral head could be taken as the model for acetabular reduction. From among 70 hips, 49 of them were confirmed of nonunion during the surgery, 21 sides were accompanied with malunion and five sides required osteotomy (pubis ischium branch and iliac crest) in order to identify the original fracture line. The trochanteric osteotomy was performed in eight sides with a Kocher-Langenbeck approach and in two sides with a combined anterior and posterior approach in order to extend the exposure.

If the post-injury duration is long and direct reduction is impossible, the soft tissue release has to be gradually performed during the reduction. The reduction clamps and Jungbluth clamp are useful for a temporary fixation and the deformity can be gradually corrected. In the delayed posterior wall fracture with dislocation or subluxation, there is often a large amount of scar in the joint, which could hinder the femoral head from locating into the acetabulum. Therefore, the bone fragment of posterior wall should be isolated from the bone scab and the scar tissue should be cleaned completely. The Schantz needle can be inserted into the femoral neck to help the traction and reduction. In our study, quadratus femoris were cut in five cases and the soft tissue that was attached to the posterior wall (such as capsule) was protected to retain the blood supply, which could further contribute to the fracture healing. Sometimes the fracture is so comminuted that the bone fragment is too small to be fixed with lag screws and using more screws might increase the risk of the screw to get into the joint. Accordingly, the combination of reconstructed and profiled plates could be used to fix the posterior wall fracture. If the defect in the posterior wall is large, the bone graft might help to restore the intact structure of the posterior wall. Five hips in our study were combined with irreparable posterior wall bony defect. Therefore, we reconstructed the posterior wall with autografts harvested from posterosuperior iliac spine.

Complications

In the study of Laird and Keating,[6] the rate of traumatic arthritis was reported to be 14%. The most common fracture patterns were reported to be those referred as the transverse or posterior wall fractures including transverse, posterior wall, transverse with posterior wall, and T-shape fractures. In the study of Johnson et al,[7] of all the fracture patterns, the worst outcome belonged to the posterior fracture followed by the transverse with posterior wall fracture. Kreder et al[8] reported that the secondary THR was not related to the fracture pattern, but the percentage of THR was apparently higher in the patient older than 50 with posterior wall fracture associated with marginal impaction. Tannast et al[9] analyzed the follow-up data from 810 patients, where 50% of the secondary THR cases received the THR in 1.5 years after the ORIF. In our study, a 47-year-old male patient with a delayed posterior wall fracture associated with femoral head posterior dislocation was admitted. The operation was performed seven months post injury. The patient developed a femoral head necrosis three months after the operation and received THR within 3 months.

The HO occurrence is similar with that of the fresh fracture. This could be related to the surgical approach of Kocher-Langenbeck, which appears to have the highest incidence of HO.[10] Prophylactic procedures were comprised of a full irrigation of the wound, oral application of indomethacin and radiation therapy.[11] Surgical treatment has been reported to be dependent on the hip function.

Risks of prognosis in delayed acetabular fractures

Period from injury to surgery

According to some recent reports, the prognosis of acetabular fracture was related to the period from injury to surgery and the quality of reduction,[12,13] such that a displacement of less than 2 mm predicted a better result even for the conservative treatment patient.[14]

The definition of delayed fracture is a dilemma by itself. In the report of Johnson et al,[7] only 52% of the patient that were injured beyond 21 days eventually gained anatomical reduction. Murphy et al[15] reported that there was no statistical difference between above or under 18 days from the primary injury. Furthermore, the age factor was only involved in the prognosis of the patients with a poor reduction. Based on a multiple-center study of 1266 patients

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from 1991 to 2006, Ochs et al[16] reported that the reduction quality significantly decreased after 11 days from the injury. Kumar et al's study showed a lower score in a patient with a 2-week delay, which was not significant.[17] Based on the follow-up data of 79 patients in a study by Deo et al,[18] 91% of the excellent and good functional patients received the ORIF under 14 days, while 78% of the fair and poor functional patients received the operation beyond 14 days. Another study from Briffa et al[19] showed that of 161 acetabular fracture patients, almost half of them with delays of more than 8.4 days got an unsatisfactory outcome. An acetabular fracture beyond 21 days is defined as a delayed fracture in our institution. The standard for this definition should not refer to the function score but should consider the bone healing. In our observation, at 21 days after acetabular fracture, no obvious callus was found and the fracture lines were clear. All the patients in this study were injured more than 21 days. Four of them were associated with a closed trauma in their head and one patient was in coma for two weeks following the severe injury. Following the consciousness, the operation was already delayed for 22 days. A large amount of callus was observed and the fracture was nearly healed. Therefore, the surgeon should pay more attention to the brain injury, which might cause an abnormal growth of callus not matching with the time of injury.

In our study, the satisfaction rate was 71.4%, which was similar to Matta's 65%[7] and Deo's 74%[18] rates. We separated all the patients into different groups based on the delayed time, greater or less than 30, 42 and 60 days. The group with no more than 42 days between the injury and the operation showed a significant difference as compared to the group with more than 42 days delay. Although they were injured for 42 days and the callus grew, primary fracture line and the anatomical landmark could still be identified in most of the cases. However, if the patient was injured beyond six weeks, the fracture might have been already healed and the fracture line might have been disappeared. There could be often a need for osteotomy in order to reconstruct the acetabulum contact and femoral head. This procedure should be performed under an X-ray fluroscopy and yet the final result was not satisfactory enough.

Delayed femoral head dislocation and injury

Many studies supported the fact that a femoral head injury could predict a poor result. Liebergall et al[20] followed up 53 patients and found that the outcome of a patient with a femoral head injury is worse than that of the noninjured patients. In a follow-up study of 108 cases by Borg et al,[21] 19 patients developed a secondary THR. The researchers related the secondary THR to the potential impact of both acetabulum and femoral head fractures. Long lasting dislocation of the femoral head could be one of the prognostic risk factors, which makes the preoperative femoral head reduction a very important corrective action for the patients with delayed fractures. Most of the 34 hip dislocations did not get a proper reduction. Furthermore, for these patients, lower limb traction was nearly useless. Based on all these results, we concluded that acetabular fractures, associated with a femoral head dislocation, should be reduced as soon as possible. A dislocation reduction should be treated more actively when the bilateral hip is dislocated, where the reduction of the femoral head and maintaining its proper position might guarantee a good function. Moed et al[22] reported that a dislocated hip joint for more than 12 hours could be a risk factor for a bad prognosis. Furthermore, the other risk factors included an age of 55 years or older at the time of injury, intra-articular comminution and osteonecrosis.

Other factors

Magill et al[23] reported the sciatic nerve injury to be another risk factor. In our study, the subjects were patients with old fractures. The acceptance rate was 63.6% in patients with sciatic nerve injuries, which was lower than the patients without any nerve injury, yet not statistically significant. During the follow-up, most of the patients with nerve injuries had varying degrees of recovery and the ones without any functional recovery had a predicted poor outcome. In our series of studies, the other associated injuries were usually treated before the acetabulum reconstruction, which did not lead to a worse consequence.

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